CHAPTER 5

SURROUNDED BY PESTICIDES

Food, water, air, and dust can all be contaminated by pesticides, and are all routes by which children can receive hazardous exposures. Numerous studies have evaluated the degree of pesticide contamination in these environmental media, and some have gone further, to associate pesticides in dust with pesticide residues on children's hands or in their urine. The majority of studies have not involved farm families, but are nonetheless relevant to children's disproportionate exposures. Some small reports do focus on farm children, including migrant farmworkers, and have measured exposures from all of these routes, often finding levels greater than those reported in studies of non-farm families.

PESTICIDES IN FOOD

> *"The children became sick when we were picking strawberries and it made them vomit. . . . Much zohite dust was spotted on the leaves and the fruit as well. Almost all of the people had brought their children. There were between 70 and 100 workers, and each one brought several children. The children started to eat the berries and then they began to vomit. Several of them became sick with vomiting and diarrhea including four of my children. I brought them to the hospital. Almost all the children that were working in the field this day became sick."*
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> Delfina Chavez, Farmworker, Mt. Angel, OR, July 9, 1998

Pesticide residues are widespread in the food supply. Data from the Food and Drug Administration (FDA) for the past nine years show that between 33 and 39 percent of the food supply in any given year contains detectable pesticide residues.111 Among domestic foods, nearly 46 percent of grain samples, 38 percent of fish and shellfish, 54 percent of the fruit, 36 percent of the vegetables, and 3 percent of the dairy products tested had detectable residues of at least one pesticide, although few of these residues violated legal tolerances.[111]

An average one-year-old's top ten favorite foods are apple juice, grape juice, oats, bananas, milk, apples, orange juice, pears, wheat, and peaches. On a body-weight basis, young children consume these foods at levels from three to twenty-one times greater than the average adult American. FDA monitoring has detected pesticide residues in

50 percent of the samples of these foods, although generally at levels below regulatory tolerances.[71] According to the National Academy of Sciences, diet is an important source of exposure to pesticides, particularly for children, some of whom are exposed to pesticide residues in food above levels considered safe by the federal government.[70]

Several recent studies have detected pesticide residues in food:

- In 1995, the USDA's Agricultural Marketing Service tested nearly 7,000 fruit and vegetable samples and detected residues of 65 different pesticides. Two out of every three samples contained pesticide residues.[12]
- Foods commonly consumed by children are likely to carry more than one pesticide. A 1993 analysis of the FDA monitoring results found 108 different pesticides in 22 fruits and vegetables commonly eaten by children; 42 different pesticides were

The Agricultural Health Study

Since 1993, a major research effort has been under way to evaluate agricultural exposures and health impacts among farm families. The Agricultural Health Study (AHS), a collaborative research project of the National Cancer Institute, the U.S. EPA, and the National Institute of Environmental Health Sciences, is the largest study to date of farm families. The study has enrolled a cohort of approximately 90,000 people in Iowa and North Carolina. Study subjects include farmer applicators (farmers who apply their own pesticides), spouses of farmer applicators, and commercial pesticide applicators. Many of the families have children, and these children are also being evaluated for exposures and health effects. The study does not include hired farmworkers, who may differ in numerous important ways, including socioeconomic status, from farm owners and pesticide applicators.

Exposure assessment in this study includes periodic questionnaires asking about crops grown, pesticide use, agricultural activities, exposures, and general information about children. A subsample of the cohort (about 200 families) will undergo measurement of pesticides via all potential routes of exposure, including food and water, inhalation, and skin exposures. Furthermore, biological measurements of pesticide metabolites in blood and urine will be performed on a subset of the study subjects. The cohort will be followed to identify a variety of health outcomes ranging from cancer to neurologic and reproductive problems.[116]

Although very little data from the AHS itself are currently available, small pilot studies have been completed to test methods that are now being applied to the larger cohort. Results of these pilot studies have been published and are discussed in this report. As more data become available from the AHS, we will have some of the information necessary to quantify the excess exposures of farm families.

The cohort under study in the AHS is overwhelmingly white (97 percent). Virtually no Latinos are enrolled. The focus on white farm owner families significantly limits the utility of this large study for predicting exposures to non-white farmworkers. Furthermore, crops grown in different geographic regions have different pesticide use patterns. In Iowa, the major crops are grains, soybeans, and corn, along with hogs and beef cattle, and in North Carolina, crops are similar to those in Iowa but also include tobacco, peanuts, yams, and cotton, as well as poultry. As a result, it may be difficult to generalize the results of this study to states such as Florida, Texas, and California where vegetables and fruits are the primary crops.

detected on tomatoes, 38 were detected on strawberries, and 34 were detected on apples.[71] Based on FDA data on U.S.-grown and imported food, the following fruits and vegetables contain the most residues of the most toxic pesticides: strawberries, bell peppers, spinach, cherries, cantaloupes (grown in Mexico), apples, apricots, green beans, grapes (grown in Chile), and cucumbers.[113]

▶ Processed baby foods can also contain pesticide residues. According to recent testing, sixteen pesticides were detected in eight baby foods sampled. Five different pesticides were found in pears, four in applesauce, and three in peaches, plums, and green beans. Residue levels were generally below those found in fresh fruits and vegetables.[114]

▶ The Agricultural Health Pilot Study, performed on six farms in Iowa and North Carolina, tested food samples collected from the farmhouses for 29 targeted pesticides. Pesticides were detected frequently on foods on these six farms at levels above those reported for the general population. In particular, elevated levels of the pesticide being applied during the monitoring period were detected in the food. The authors conclude that the results show potential dietary exposures above expected values, particularly to pesticides that are currently being applied on the farm and to environmentally persistent pesticides.[115]

Thus the general public is exposed to numerous pesticides in food at levels that can pose a potential risk to a child. There are few data about farm children's dietary exposures to pesticides, although preliminary results from the Agricultural Health Study indicate that exposures to farm children may be higher than to thegeneral public. Anecdotal reports of farm children picking and eating foods directly from the fields are common, although no studies have attempted to measure these exposures.

PESTICIDES IN DRINKING WATER

> *"We have to bathe in the irrigation channels by the fields. We know they are filled with pesticides, but we can't live without removing the dirt of our daily work."*
>
> Anonymous Farmworker, California[117]

> *". . . all the water that comes from the agro fields . , , it comes right into here . . . every day in our house, our water would usually come out sandy and had a pink color or yellow color.* We *didn't think anything about it.* We *would just wonder,* 'Well, gee, what *is wrong?'* Well, time *went on and on. Our water was getting worse. Our sink water would stink like rotten eggs . . . we've had bad water quality."*
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> Marta Salinas, McFarland, California[14]

Pesticides have proven to be a pervasive problem in surface waters in many parts of the United States. Because surface waters may be used for drinking, this contamination can be a real threat. Although drinking water problems can be an issue in all parts of the country, agricultural regions are the most heavily impacted. Farm families, because they are more likely to drink from private wells or small water systems, are the most at risk. There are about 54,000 small water systems serving 1,000 or fewer people in the United States, which adds up to approximately 20 percent of the total population. Two-thirds of these systems serve communities with 500 or fewer residents. These small systems are primarily located in rural, often agricultural, areas, and the small utilities often cannot afford the equipment and qualified operators necessary to ensure compliance with safe drinking water standards.118

The following examples describe some known water contamination problems:

- In 1992, U.S. EPA reported that 132 pesticide-related compounds, 117 parent pesticides, and 16 pesticide degradates had been found in ground water in 42 states.[119] Widely detected pesticides included aldicarb, alachlor, the triazine herbicides, 2,4-D, and nearly a dozen others. The U.S. EPA also has found that one out of every ten public water supply wells is contaminated by at least one pesticide; the EPA infers from these data that nearly 10,000 community drinking water wells and about 440,000 rural domestic water wells contain pesticides, although most do not exceed the EPA's existing drinking water standards.120
- In the period from 1991-1995, the U.S. Geological Survey (USGS) sampled from 5000 streams and wells and found at least one pesticide in every stream and in at least half of the wells sampled. The triazine herbicides (atrazine and simazine), 2,4-D, and several organophosphates including chlorpyrifos and diazinon were the most commonly detected of the 85 pesticides assayed.[121]
- A 1997 survey of water contamination found that about 4.3 million Americans in 245 communities are exposed to levels of carcinogenic herbicides in drinking water that exceed the U.S. EPA's benchmark of "acceptable" cancer risk (one excess cancer case in a population of a million).[122] Commonly used agricultural herbicides contaminate the tap water of 374 Midwestern towns. Over ten million Americans in the Midwest and Chesapeake Bay region alone are exposed to herbicides in their drinking water. In addition, up to ten different herbicides and metabolites or derivatives were detected in individual tap water samples.[122]
- A 1994 studv found that drinking water is often contaminated with two or more of the common herbicides, atrazine, cyanazine, simazine, alachlor, and metolachlor. In all, some 67 different pesticides and pesticide metabolites have been detected in midwestem sources of drinking water. People in small rural communities, and children in particular, are at high risk; over 400,000 people in 98 rural communities were found to face cancer risks from 10 to 116 times the federal benchmark.123
- The State of California reported that 22 pesticides were detected in a total of 436 groundwater wells in 1996. The most commonly detected compounds were herbicides, and detections were much more frequent in agricultural regions of the state.124

In the heat of the fields, a young tomato picker stops for water from the back of a truck.

J.B. McCourtney/Impact Visuals

Although the average levels of pesticides in water are low, for those families whose water supply is contaminated at levels significantly above the average, drinking water can be a major source of exposure.

In agricultural regions, small water systems and private wells are often shallow and poorly protected, making them more likely to be contaminated with pesticides and other pollutants than larger city supplies.

In agricultural regions, small water systems and private wells are often shallow and poorly protected, making them more likely to be contaminated with pesticides and other pollutants than larger city supplies. Other small utilities in rural areas may use surface water that is-highly vulnerable to pesticide runoff contamination.[120, 121] Small utilities also often lack the economies of scale enjoyed by large utilities, which makes it harder to use more expensive, state-of-the-art water treatment systems capable of removing pesticides. Moreover, in some states, small utilities can get waivers of monitoring requirements or special "variances" or "exemptions" from water treatment requirements that are not generally available to larger water suppliers.125 As a result of these factors, and the simple fact that agriculture can contaminate local waters, farm families are likely to receive higher exposures to pesticides from drinking water than other households. These exposures may occur from drinking the water, or from bathing or showering because many pesticides are volatile in warm water and can be absorbed through the skin or inhaled in the shower. These routes of exposure should be considered in evaluating total exposures to pesticides.

PESTICIDES IN OUTDOOR AIR, DRIFT, AND FOG

> *"I believe we here in the colonias are more exposed to the chemicals due to the planes that go by, and they don't care if the wind is strong or if there is no wind. We have been affected some five or six times right here in our house. Once the plane flew over and I think it opened the valve and we were very sick. And the field is very close, then they don't tell us that they are going to spray; they don't take us into account for anything. So I think this needs to change because they are killing us little by little. One of the little ones, when cotton season starts, always sweats and gets a bad rash on the face with lots of pimples. The doctor says it's a skin disease, but he does not say it's the chemicals that are already on his skin . , , The school is very close by, Kelly School, so a lot of children are being affected by the chemicals."*
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> Worker, Hidalgo Park, Public Meeting in Pharr, TX, April 25, 1996

Outdoor air concentrations of pesticides in agricultural regions may be significant, particularly for those applied as a gas for fumigation, by ground broom, or by broadcast spraying. Children who live in agricultural regions may receive airborne pesticide exposures when playing outdoors. Infiltration of homes by outdoor air could also result in airborne exposures inside the home.

Monitoring has revealed that airborne pesticides present a pervasive problem:

- In California, two weeks of ambient air monitoring near sugar beet and potato fields for the fumigant and carcinogen Telone II (1,3-dichloropropene), measured ambient air levels exceeding the federal reference concentration (safe level) for chronic inhalation exposures. Chronic exposure to the levels measured is predicted to result in more than one excess cancer per every five thousand people exposed, far greater than most federal standards for acceptable levels of risk.[126] Even short-term exposures to elevated levels of this chemical may cause respiratory problems.

▶ Methyl bromide is an odorless, colorless, acutely poisonous and neurotoxic gas that has also been shown to deplete the ozone layer. Air monitoring near a fumigation chamber where methyl bromide was used revealed exposure levels more than 17 times higher than the California EPA regulatory limit for airborne exposure to this toxicant.[126]

▶ In the same study, ambient air levels of the breakdown product of metam sodium, an irritant, acute poison, and developmental toxicant, were over tenfold greater than the reference exposure level for acute eye irritation near fields where soil was being fumigated.[126]

▶ A 1996 report by the Environmental Working Group documented elevated air levels of methyl bromide over two-to-three day periods in two residential neighborhoods near California fields. The California state health standard for short-term exposure to methyl bromide is an average of 210 ppb dver a 24-hour period, yet peak levels were as high as 665 parts per billion (ppb) in Castroville and up to 1,900 ppb in Ventura, with an average level over the three-day period of 294 ppb. Elevated levels of this fumigant were detected over 400 yards from the application site, six times the allowed buffer zone, in a residential area with a day care center.127

The California state health standard for short-term exposure to methyl bromide is an average of 210 ppb, over a 24-hour period, yet peak levels were as high as 665 parts per billion (ppb) in Castroville and up to 1,900 ppb in Ventura.

▶ Fog samples gathered in suburban Maryland and in agricultural regions of California revealed up to 16 different agricultural pesticides. The pesticides detected included organophosphates, triazines, dinitroaniline (pendimethalin), and chlor-acetanilides (alachlor, metolachlor). The levels of organophosphates and their oxygen analogues in fog were often two or three times greater than levels reported in rain. The maximum measured level of the highly toxic parathion oxygen analogue (paraoxon) was high enough to cause sigrtificant acute cholinesterase inhibition. In addition, volatile, fat-soluble pesticides were found in fog at concentrations far greater than expected.128 Pesticides in fog can enter the body in numerous ways. The fog vapor and pesticides can be inhaled directly into the lungs, absorbed through mucus membranes, or swallowed.

▶ A small Minnesota study found that an application of two herbicides by ground-broom sprayer 50 yards upwind from a farmhouse resulted in a three-to-fourfold elevated concentration of both chemicals in outdoor air adjacent to the farmhouse-where a child playing in the yard could be exposed to the toxicants. Interestingly, there was also a 50 percent increase in the concentration of one of the herbicides inside the farmhouse.*29

▶ An Israeli study detected small reductions in plasma and whole blood cholinesterase in residents living near fields during spraying season compared with others living further from the fields. The same individuals had normal plasma and whole blood cholinesterase levels off-season. In addition, infirmary records indicated a significant increase in visits for symptoms such as respiratory problems, headache, and eye irritation on days when organophosphates were sprayed.[130] These data indicate that exposures to organophosphate pesticide drift may result in symptoms and slight cholinesterase inhibition in nearby residents.

The potential for children living on or immediately adjacent to fields to be exposed to airborne agricultural pesticides at levels not deemed safe for human exposure must be further investigated and taken into account when evaluating total exposures.

PESTICIDES IN INDOOR AIR

Pesticides are known to accumulate in indoor air at concentrations one or two orders of magnitude higher than in outdoor air. For farm children, indoor air exposures may include agricultural pesticides never used indoors.

The Non-Occupational Pesticide Exposure Study (NOPES), which focused on adult exposures in non-agricultural families, measured personal exposures to pesticides in household air. Striking results from this survey included significant regional differences, with higher exposures in warmer regions (Jacksonville, Florida) and lower exposures in temperate regions (Springfield and Chicopee, Massachusetts). There was significant seasonal variation in both geographic regions.' The average number of pesticides detected in indoor air in households considered to have "high pesticide usage" was eleven, while "medium usage" homes had an average of seven detectable target pesticides, and "low" use homes had an average of five different pesticides detectable in indoor air. As many as 20 different pesticide residues were found in indoor air in homes. The most prevalent pesticides were chlorpyrifos, diazinon, chlordane, propoxur, and heptachlor.[131] Because these pesticides were all once registered for home use (although some no longer are) the residues most likely stemmed from use indoors, sometimes in the distant past. Extrapolation from the NOPES study indicates that, for adults without occupational pesticide exposures, indoor air inside the home may account for as much as 85 percent of the total daily exposure to airborne pesticides.132

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Pesticides in indoor air tend to concentrate near the floor. Chlorpyrifos, for example, was nearly four times more concentrated at 12-25 cm (about 5-10 inches) from the floor compared with greater than 60 cm (2 feet) from the floor in a room with a window open for ventilation.[74] This indicates that there is less air mixing near the floor, and that the breathing zone of an infant or crawling toddler is likely to contain a greater concentration of pesticides during certain ventilation conditions than the adult breathing zone. Pesticides in the air can also deposit onto surfaces, including carpets, kitchen counters, and children's toys.[133] Therefore airborne pesticides eventually create tactile exposures through skin contact or children's hand to mouth behavior. The deposited residues, in turn, can become airborne again when dust is stirred up, or through evaporation from surfaces, resulting in a veritable swirl of pesticides throughout the home.

An investigation in Minnesota measured air levels of various pesticides both indoors and outdoors on farms.[129] This study clearly documented "take-home" exposures of pesticides. For example, on "Farm 1 A," the farmer sprayed hogs with lindane to control mange. He then visited "Farm 1B" for dinner, still wearing his work clothing. Finally, the farmer went home and changed his clothes. Measurements taken over the three days surrounding the spraying event revealed that the lindane levels in outdoor air on Farm 1A increased by fortyfold, while indoor air levels increased by twenty-four-fold. At farmhouse 1B, about a quarter mile from the site of outdoor spraying, lindane levels in indoor air increased by fourfold. The indoor air levels at farmhouse 1B were likely due to off-gassing of pesticides from the farmer's clothing, while the greater indoor air levels in farmhouse 1A may be due to a combination of infiltration of outdoor air and off-gassing from clothing. In the same study, similar increases in pesticide levels in indoor air were measured following agricultural applications of other insecticides and herbicides. "Background" air levels of various pesticides, including alachlor, atrazine, lindane, and trifluralin, were substantially higher in and near Minnesota farm homes compared with the urban homes in Jacksonville and Springfield studied in the NOPES study. In addition, indoor air levels were up to ten times higher than outdoor air levels for many pesticides; this was generally true even when the pesticide was applied outdoors. The authors concluded,

> *This study demonstrates that a direct relationship can exist between outdoor application of a pesticide by a farmer and subsequent elevated indoor air concentrations of the pesticide in his home. The data suggest that transport of residues on the fanner's work clothing and/or track-in on shoes as well as infiltration of aerosol spray drift can be mechanisms contributing to elevated indoor air levels.*[129]

The elevated pesticide levels in indoor air, and the documented presence inside farmhouses of pesticides registered for agricultural use only, indicates a source of exposure to a substantial subgroup of children that must be considered when setting pesticide use standards.

Whereas pesticides that remain outdoors are generally broken down by sun, rain, and soil microbes, indoors they may accumulate undegraded in carpets and furniture for years,

PESTICIDES IN HOUSE DUST

Dust inside homes is known to collect pesticide residues. These residues may include pesticides used for home pest control, including compounds used years ago which persist in carpets or seep out of foundations that were treated for termites, and those used outdoors that are tracked into the home on shoes. An estimated 31 percent of indoor dust originates in outdoor soil.[134] Researchers estimated that tracking-in of outdoor soil was the principal source of about half of the pesticides detected in the indoor air of one monitored home.[135] Whereas pesticides that remain outdoors are generally broken down by sun, rain, and soil microbes, indoors they may accumulate un-degraded in carpets and furniture for years. For small children, house dust is a major route of exposure to pesticides, lead, and allergens.[136–138] Because of children's lower body weight and higher dust ingestion, their risk from toxic chemicals in dust is estimated to be at least 12 times greater than that of adults.[137]

A variety of methods have been used to collect and quantify pesticide residues in dust, including modified vacuum cleaners, polyurethane foam rollers, cotton gloves, and bare-hand presses.[139–141] A recent publication also demonstrates the validity of sampling dust from used household vacuum cleaner bags.142 The various methods have been found to be comparable, making it possible to test for pesticide residues in house dust and to quantify the range of concentrations found in homes, particularly in impacted areas such as in agricultural settings.

Homes In Non-Agricultural Areas

Household and yard pesticide use is very common among the general population. A study in Missouri found that 97.8 percent of families use pesticides at least once during the year, and 70 percent of people reported using pesticides in the home or yard during the first six months of a child's life.[143] The commonly used herbicide 2,4-dichlorophenoxyacetic acid (2,4-D), which has been linked in both humans and dogs to non-Hodgkin's lymphoma, can be carried indoors after application on lawns. One investigation revealed that 3 percent of dislodgeable residues of 2,4-D on a lawn was tracked indoors and accumulated in carpet dust.[144] Although 2,4-D and many other lawn and garden pesticides normally break down fairly quickly into less toxic forms from outdoor weathering factors such as wind, rain, sun, and soil microbes, they can linger in the indoor environment for years. Carpets, house dust, and furniture become long-term sinks for pesticides.132 Calculations based on a single lawn application of 2,4-D indicate that detectable levels of the pesticide can remain in carpet dust up to one year after a one-time outdoor application.[144]

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A variety of pesticides have been detected in non-farm homes:

- An in-depth study of a home in San Antonio, Texas, revealed detectable residues of 16 pesticides in the living room carpet. Gradients of many of these pesticides were apparent from the garden onto the front doorstep and into the carpet indicating that the pesticides were likely transported into the home primarily on shoes.135 Thus, "tracking-in" of pesticides is likely to be fairly common and should be considered for all pesticides which are registered for use on lawns and gardens.
- The Non-Occupational Pesticide Exposure Study (NOPES) measured levels of selected pesticides in carpet dust of nine homes. The average number of targeted pesticides measured in carpet dust in any single home was 12, compared to 7.5 pesticides on average in the air samples in the same residences. Many of the less volatile pesticides were not detected in indoor air but were found in carpet dust.7 Older carpets had the highest levels of pesticides, indicating accumulation over time. Numerous pesticides that have been banned in the United States were detected and quantified in carpet dust, particularly in older homes. These included DDT, heptachlor, aldrin, dieldrin, and chlordane.[145]
- Similar results were found in numerous other small studies in a variety of settings. A small study in the Raleigh-Durham area of North Carolina found a range of 8 to 18 different pesticides in dust in the nine homes sampled. Pentachlorophenol, a wood preservative and endocrine disrupting chemical, was detected in every household sampled, while chlorpyrifos and numerous organochlorine pesticides

In the case of propoxur, the estimated exposure for a six-to-nine month old child playing on a carpet after application following the label instructions was above the human Lowest Observable Adverse Effect Level (LOAEL) for acute health effects.

including DDT were found frequently.[140] Sampling in this study of pesticides in indoor air at 6 inches off the ground (the breathing zone of a crawling toddler) and of pesticides in dust revealed that the dust ingestion of certain pesticides could exceed inhalation exposures for a young child in some of the homes sampled.[132]

- The Lower Rio Grande Environmental Exposure Scoping study looked for a wide variety of chemicals, including pesticides, in the spring and summer of 1993 in a small number of homes in a farming area.[146] Unfortunately no children were studied during the pilot phase. This study showed that levels of chlorpyrifos measured in indoor air and dust and the levels of a metabolic byproduct of chlorpyrifos in the urine of adults living in the house were highly correlated.[147] Thus in adults, levels of pesticides in indoor air and dust in the home are strong predictors of actual exposure. In children, there is a linear correlation between the concentration of lead in indoor dust and blood lead level.[148] Although the relationship between pesticides in house dust and levels in children's body tissues and urine needs further investigation, the data on lead demonstrate that a toxicant in house dust can get into children's bodies.
- Evaluations of pesticide levels in carpet dust in 362 homes with children throughout nine states revealed wide variability in the concentrations of pesticides identified. Two pesticides, orthophenylphenol (a fungicide and disinfectant) and chlorpyrifos, were found in the majority of homes sampled (96 percent and 67 percent respectively). While the median concentration of chlorpyrifos measured in dust was not very high (0.54 µg/g), the maximum measured concentration exceeded the median by nearly a thousandfold (324 µg/g). This range of variability was also typical of other insecticides measured in this study, including the organochlorines (DDT and dieldrin), the synthetic pyrethroid (permethrin), and the carbamates (carbaryl and bendiocarb).[149] This study confirms that some children are exposed at levels many times greater than the average child.
- The California Department of Health Services reviewed an industry study on pesticide absorption from carpets following indoor pesticide use. In the case of propoxur, the estimated exposure for a six-to-nine month old child playing on a carpet after application following the label instructions was above the human Lowest Observable Adverse Effect Level (LOAEL) for acute health effects. For dichlorvos, the predicted dermal exposure to a six-to-nine month old child following application approached the rat oral lethal dose for 50 percent of the animals (LD_{50}). For chlorpyrifos applied similarly, the dermal dose was nearly 90 times the minimal human response level for acute symptoms.[150] Although some of these specific pesticides are no longer used for indoor broadcast applications, these estimates illustrate the significant potential of infant and toddler exposure from contact with pesticides in carpet dust.

Farm Homes

Pesticides used on family farms end up in increased concentrations inside the home, compared with homes in non-agricultural areas, as the following studies show:

▶ A study of dust exposures among farm children was carried out in an apple, pear, and cherry-growing area of Washington State.6 A total of 26 farming families, 22 farmworker families, and 11 non-agricultural families participated. All had at least one child between the ages of one and six. Soil from outdoor play areas was sampled, as was household dust from indoor play areas. These samples were analyzed for the presence and concentration of four organophosphate insecticides: azinphos-methyl, phosmet, chlc . pyrifos, and ethyl parathion. Residues found in household dust and soil were almost exclusively due to agricultural use, rather than home use of these products. One or more of the four target pesticides was found in 58 percent of the soil samples outside agricultural homes and in only 18 percent of soil samples near comparison homes. At least one of the pesticides was found in 100 percent of the house dust samples from farmworker and farmer homes, and all four of the targeted pesticides were found in 62 percent of farm homes. In comparison, in non-agricultural homes, only 9 percent of dust samples contained all four pesticides. Median indoor pesticide concentrations in house dust were generally 17 to 100 times higher than outdoor soil levels, although both were significantly higher in farm homes. Furthermore, maximum detected concentrations were generally 10 to 100 times greater than the median concentration detected, and the range of detected concentrations was generally much broader in farm homes.

Paul Mugge is one of the family farmers profiled in NRDC's *Fields of Change* whose concern over chemical inputs led him to alternative farming techniques that dramatically reduced pesticide use.

In the Washington State study, some agricultural pesticides were detected (albeit at lower concentrations) even in non-farm homes located more than a quarter of a mile from an orchard. This may indicate that drift of agricultural pesticides can contaminate non-farm homes in an agricultural region. It is also notable that almost all of the pesticide handlers in the agricultural families reported using appropriate personal protective equipment and did not bring their personal protective equipment into the home. Nearly all of the pesticide handlers also reported washing the clothing worn under their protective clothing after each pesticide application. Thus, although the pesticide applicators were taking steps to minimize take-home exposures to their families, their children were still at risk from elevated exposures to agricultural pesticides.

▶ A small pilot study in Minnesota that tested methods for the Agricultural Health Study evaluated exposures to farmers at four family farms, measuring outdoor and indoor air levels, and analyzing outdoor soil, indoor dust, drinking water, and hand wipes of children. For several herbicides and fungicides, which would never be applied indoors, the indoor air level was up to 10 times higher than outdoor air levels. Furthermore, as in Texas, an increasing concentration gradient was found for numerous pesticides from pathway soil to entryway soil to, finally, carpet dust. Herbicides such as alachlor and atrazine, chlorpyrifos, and DDT were all found on the hands of a three-year-old child.[151] These pesticides reflected the pattern found in household dust in that farmhouse, and implied that this child was exposed to agricultural pesticides not registered for home use.

▶ An additional report from the Agricultural Health Study in Minnesota, Iowa, and North Carolina reported that house dust levels of herbicides such as alachlor, metolachlor, atrazine, and 2,4-D increased by tenfold to one hundredfold in one home following field applications. Detection frequency of atrazine in house dust on Iowa farms increased from 75 percent to 100 percent during the application season, the median concentration increased tenfold, and the maximum detected concentration increased one hundredfold. When compared to the herbicide levels detected in non-farm homes, farmhouses had significantly greater frequency of detection and elevated concentrations in dust. The authors conclude, "Usage of herbicides and other agricultural pesticides on the family farm may significantly elevate the potential for exposure of young children to these chemicals while growing up on the farm."[10]

Contact with house dust, including inhalation, ingestion, and dermal contact, can be primary routes of pesticide exposure for small children. Extensive experience with lead exposure has conclusively demonstrated that when levels of lead are elevated in house hold dust and soil, blood levels of this toxicant are also elevated in children.[148, 152-156] These multiple and cumulative exposures must be considered when setting pesticide tolerances in order to avoid repeating the mistakes of the past.

PESTICIDES ON FARM CHILDREN'S HANDS

"We think of our children who are at home and about the future of those children. If we do nothing, perhaps they will say 'my parents did nothing, and they could have stopped this."

Eduardo Montoya, Farmworker[14]

Numerous pesticides are known to penetrate the skin, so exposures from pesticides on hands would be both oral and dermal.

All studies that have investigated dermal exposures to pesticides in adults or children have found that skin contact is a major route of exposure, particularly in children. Numerous pesticides are known to penetrate the skin, so exposures from pesticides on hands would be both oral and dermal.[157] Hands moist with saliva collect more pesticide residue than dry hands.[158] Because young children often have wet, sticky, saliva-moistened hands, they are likely to collect more pesticide from carpets and other surfaces than would be predicted extrapolating from dry-hand presses. Farm children get pesticides on their skin from household pesticides, lawn and garden pesticides tracked into the home, and agricultural pesticides in the soil, or that enter the home through drift or on clothing.

Several small studies have shown that pesticide residues can accumulate on many common objects that children touch:

▶ A total exposure estimate after broadcast spraying of chlorpyrifos in a three-room residence revealed that the total estimated absorbed dose for an infant in the days following the pesticide application were between 1.2 and 5.2 times the No Observable Effect Level (NOEL), and between 10 and 50 times the human reference dose (RfD).

Dermal absorption represented approximately 68 percent of the total projected exposure to an infant.[159]

▶ A recent study revealed that children's toys can accumulate pesticide residues and may represent significant sources of exposure.[133] The investigators sprayed chlorpyrifos inside a home according to the label directions, and after the recommended airing period placed plush and plastic toys in the room. The toys were tested for pesticide residues periodically over a two week period. Chlorpyrifos accumulated on both types of toys, apparently due to absorption from the air into the plastic and felt materials. A multi-pathway exposure estimate (not including food and water ingestion) based on the scenario of a three-to-six year-old child playing in the room one week after an application of the pesticide revealed a total exposure estimate more than 20 times greater than the U.S. EPA reference dose. A child in this environment would receive about two-thirds of their total dose from hand-to-mouth exposure, about one third from skin penetration, and a small amount from inhalation. Label instructions regarding reentry times into indoor environments after pesticide applications are based on the period of time needed for air levels (in the adult breathing zone) to decrease to "safe" levels. These reentry times do not account for the fact that pesticide vapors can be more concentrated near the floor, and for the deposited pesticides on surfaces that can result in dermal exposures to children.

Hand wipes of farm children taken in the days following pesticide application by the father revealed significant residues of the same pesticides that the father had recently applied on the farm.

▶ A small study of children from middle class non-farm families in North Carolina found that there is a strong correspondence between pesticide concentrations detected on children's hands and levels found in carpet dust in the home, Among the four child participants, between one and six different pesticides were recovered by hand rinse sampling. Pesticides detected on children's hands included chlordane, heptachlor, pentachlorophenol, chlorpyrifos, and dieldrin. It is notable that several of these were banned but are still persistent in the indoor environment, and still causing exposures to children.[140]

▶ In a small study in Minnesota, hand wipes of farm children taken in the days following pesticide application by the father revealed significant residues of the same pesticides that the father had recently applied on the farm. Similar pesticides and quantities were found on children's hands on sequential days, and particular residue profiles were found consistently in different families. On three farms, investigators detected a total of 17 different pesticides on the hands of non-working children ranging from age 3 to age 15.[160] Eight pesticides, including alachlor, atrazine, 2,4-D, dicamba, pentachlorophenol, chlorpyrifos, propoxur, and DDT were all found on the hands of one three-year-old child living on a farm. On another farm, a four-year-old and an eight-year-old child also had residues of nine pesticides detected on their hands.[160]

▶ In an in-depth investigation of four Iowa family farms, there were significant differences between pesticide detections during the application season as opposed to during a non-application period, even when the pesticides were applied miles from the farmhouse. A total of five herbicides and eight insecticides were. detected on the hands of wives and children who were not directly involved in farm work during the application season.[161] An average of more than two pesticides was detected per hand wipe and concentrations were higher compared to the average of 0.4 pesticides detected per wipe during the non-application season. Strong correlations were observed between levels of individual pesticides in indoor air, carpet dust, on food. preparation surfaces, on the mother's hands, and those levels on the child's hands. One three-year-old child had atrazine and metolachlor on his hands after his father . applied these herbicides on the farm. Both pesticides were also found in the carpet dust. It is clear from this study that pesticide use by a family member outside the home can result in elevated levels of the pesticide inside the home, and ultimatelv result in exposures to family members.

A total of 12 different pesticides were detected in the house dust samples. Two pesticides, diazinon and chlorpyrifos, were found on the hands of three out of the five farmworker children sampled.

▶ In a pilot study of ten homes and one day-care center in the San Joaquin valley, researchers from the California Department of Health Services demonstrated the feasibility of performing high quality testing of farmworker homes for pesticide residues. Approximately 50 pesticides were used within one mile of the town during the months preceding the testing. Samples of house dust were collected, along with hand wipe samples from the toddlers in each family An accompanying questionnaire obtained information about pesticide use in the home, parental occupation, and the child's activities." Although home pesticide storage and use appeared generally to be lower among farmworkers, pesticide loading in house dust was generally greater. A total of 12 different pesticides were detected in the house dust samples. Two pesticides, diazinon and chlorpyrifos, were found on the hands of three out of the five farmworker children sampled, at levels as high as 100 nanograms. None of the children in non-farmworker homes had detectable pesticide residues on their hands. A screening risk assessment revealed that the diazinon exposures to two of the farmworker children could exceed the U.S. EPA's chronic reference dose from hand-to-mouth exposure alone, The reference dose is set at a level that is predicted to cause no long-term health effects, so any exceedance constitutes a risk.

All of the studies concerning residues of pesticides on children's hands and toys have been small, mostly pilot investigations involving only a few families. The California farmworker pilot study revealed concentrations of organophosphate pesticides on the hands of toddlers that have potential toxicological significance. The knowledge that agricultural pesticides can be brought into the home, accumulate in carpet dust, and end up on children's hands should be considered when evaluating cumulative exposure and risk from pesticides, even those not registered for household use.

CONFIRMING EXPOSURE: PESTICIDES IN BLOOD AND URINE .

Few studies have been done involving biological monitoring for environmental pesticide exposures, particularly among children. Analytical methods capable of detecting residues of pesticides in blood or urine are still quite limited. Only a few laboratories in the U.S. are capable of detecting low level exposures to some of these compounds accurately and precisely. In fact, only the persistent organochlorine pesticides, most of which are banned, are routinely measured in blood. A panel of 12 pesticide metabolites can be measured routinely in urine at the National Center for Environmental Health.[162] Most of the organophosphate pesticide residues, and as many as eleven herbicides can reportedly be measured in urine.163 Yet there are numerous pesticide active ingredients and degradation products that are not readily measurable in humans, or are not measurable at all. In the cases where the methodology exists to measure pesticides in humans, residues are frequently detected, and correlate with environmental exposure levels. It would be particularly helpful to have more data on the levels of pesticides in the blood and urine of farm children in comparison with children who do not live in agricultural regions.

Only a few laboratories in the U.S. are capable of detecting low level exposures to some of these pesticide compounds accurately and precisely.

NON-FARM FAMILIES

Testing suggests that pesticide residues in human bodily fluids are common:

- There is evidence that the levels of pesticides in house dust are correlated with levels of the same pesticides measured in human blood. This information is based primarily on a small study in Colorado in which positive correlations were found between pesticides in dust and pesticides in blood.[164] This study did not evaluate other routes of pesticide exposure including food, water, and air.
- In the National Health and Nutrition Examination Survey (NHANES III, 1988–1994), a sample of over 900 adult volunteers from all regions of the country, ages 20 to 59, was recruited for sampling of a panel of pesticides in urine.8 Farm populations were not specifically examined in this study, and children were not sampled. Only about a dozen pesticides that are readily metabolized into water-soluble products and eliminated in urine could be measured. Metabolites of two organophosphate pesticides, chlorpyrifos and parathion, were detected in 82 percent

and 41 percent respectively of the people tested. Both chlorpyrifos and parathion are major agricultural pesticides; chlorpyrifos is also registered for use in the home. Pentachlorophenol, a wood preservative, was also commonly found, detected in 64 percent of the people sampled, and a metabolite of p-dichlorobenzene, a carcinogenic pesticide used in mothballs and toilet deodorizers, was detected in the urine of 98 percent of people tested.[165] These findings indicate that low-level exposures to pesticides are extremely prevalent even in the adult general population of the United States.

► All 197 children in an Arkansas community had detectable residues of pentachlorophenol in their urine at levels as high as 240 ppb. A metabolite of p-dichlorobenzene was also detected in 97 percent of the children. The herbicide 2,4-D was found in the urine of 20 percent of the children, even though it is extremely short lived in the body, implying that one out of five children was exposed to this pesticide shortly before their urine was collected for analysis.9 This community was seen as fairly representative and not disproportionately exposed, implying that pesticide exposures are ubiquitous among children in the United States today.

All 197 children in an Arkansas community had detectable residues of pentachlorophenol in their urine. The herbicide 2,4-D was found in the urine of 20 percent of the children, even though it is extremely short lived in the body.

FARM FAMILIES

There is evidence that farm families experience elevated levels of pesticide residues in their blood and urine:

► A report from the Agricultural Health Study indicates that agricultural families can receive an absorbed dose of pesticides after application by a member of the family. The report used indoor air sampling, hand wipe sampling, serum, and urine monitoring to evaluate exposures to the family of one farmer applicator. The farmer applied carbaryl to pumpkins using a hand-cranked duster. His serum, carbaryl levels rose by three-orders-of-magnitude following use of the pesticide, and the carbaryl metabolite was detectable in his urine. Urine metabolite measurements on the spouse and two children demonstrated a doubling of excretion of the carbaryl metabolite following application of the pesticide. These results were seen even in the absence of a quantifiable increased carbaryl concentration in indoor air or house dust.166

Residents living near fields sprayed with organophosphate pesticides had small reductions in plasma and whole blood levels of the neurotransmitter enzyme cholinesterase during spraying season compared with residents living further from the fields, and with their own cholinesterase levels off-season. At the same time, infirmary records indicated a significant increase in visits for certain symptoms on days when organophosphate pesticides were sprayed. Symptoms included respiratory problems, headache, and eye irritation.[130] These data indicate that exposures to organophosphate pesticide drift may result in quantifiable cholinesterase inhibition in nearby residents.

► Preliminary results from the Agricultural Health Study reveal that elevated blood serum pesticide levels have been detected in some farm families. The hazardous pesticide dieldrin, which has been banned in the United States since 1987, was found at significantly elevated levels in the blood of all members of one of the six farm families sampled. Further investigation revealed persistently elevated levels of this pesticide in food samples on the farm, although all legal food uses of this pesticide were canceled in 1974. Other persistent pesticides identified in the blood of farm families included chlordane and trans-nonachlor.[167] This finding may have significant implications for all environmentally persistent pesticides. If the dieldrin is determined to come from persistently contaminated farm soil, then it *is* even more important to stop using environmentally persistent pesticides, clean up the contaminated soil, and consider the cu ıulative risks from use of these toxic chemicals in the past.

- Farm children under age six in a fruit growing region of Washington State were tested for urinary dimethylthiophosphate (DMTP), a metabolite associated with exposure to the organophosphates azinphos-methyl and phosmet, two highly toxic agricultural pesticides not registered for use in the home. The testing compared 46 families with a member involved in pesticide application and whose residence was within 200 feet of an orchard with 13 families who had no members working in agriculture and who lived farther from orchards. DMTP was detected in 66 percent of the farm children at a median concentration four times higher than in comparison children. However, DMTP was also detected in approximately 40 percent of non-farm children.12 The non-farm children may have been exposed from dietary sources, pesticide drift, or contaminated soil and dust in this agricultural region.

In this same study, younger children tended to have higher pesticide concentrations in their urine than older children, consistent with expectations about disproportionate exposure. Children living closer to an orchard also tended to have slightly higher pesticide residues in their urine. The habit of wearing work shoes inside the home also correlated with measured exposure among the children of pesticide applicators. The methodology in this study may have tended to underestimate exposures due to the limited panel of urinary metabolites evaluated. Thus this study proves that childhood exposure to agricultural pesticides in farm areas does occur and can be significant, but the limitations of the study make it difficult to use for actually quantifying total exposure.

Socio-Economic Factors

There is a consistent association between higher residues of organochlorine pesticides in blood serum and black race and lower social class.[168] No similar studies have been done of Latino farmworkers, but exposures are likely to be similarly elevated. Many farm workers are non-white and are known to bear a disproportionate burden of exposure.[169] These associations indicate yet another reason for concern over certain disproportionately exposed groups of children. Non-white poor children living in farm communities are the most likely to be impacted by pesticides and are the most likely to suffer from any potential health effects from this exposure.

There is a consistent association between higher residues of organochlorine pesticides in blood serum and black race and lower social class.

Methods should be developed to measure levels of all pesticides used in our environment in both environmental media and in human tissues or urine. Such methods should be applied to farm children and other particularly exposed populations to quantify the total exposure among these groups.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

All children are surrounded by pesticides, although evidence suggests that farm children receive greater exposures from more sources than other children. Cumulative exposures from all sources can result in significant health risks. When exposures have been evaluated, they frequently approach or exceed the "safe" reference dose for individual pesticides. The Food Quality Protection Act requires that U.S. EPA take into account all routes of pesticide exposure in tolerance decisions. In addition, any exposures must be shown to pose a negligible risk to children.

Although the exposure data are limited, particularly with regard to migrant farmworker children, and lack the large study sizes that would allow quantitative extrapolation, there is ample evidence that children are exposed to pesticides through food, water, indoor and outdoor air, soil, dust and skin contact with contaminated surfaces. All of these routes must be considered in making the determination, as required by the FQPA, that there is a reasonable certainty of no harm to children. In the case of children living on agricultural land and children whose families work in the fields, there is now sufficient scientific evidence to indicate that take-home exposures do occur. As a result, even pesticides that are labeled for agricultural use only can reach children who live in these homes. It is not sufficient to conclude that because a pesticide is not registered for household use that no household exposures occur.

We cannot await absolute scientific proof of harm while allowing known exposures to continue unabated.

The research we have compiled for this report suggests that the organophosphate pesticides pose a particular threat to farm children. These are ubiquitous chemicals that share common acute and chronic effects. Some persist in the environment, particularly indoors, and pose a combined risk of neurotoxicity. They are used on crops as well as in the household and therefore are found in most household dust and air. Several studies have found levels of organophosphates in dust and on the hands of children that are likely to lead to significant exposure.

Further investigations of farm children are needed. Larger-scale exposure assessment studies will confirm and further quantify the extent of exposure among this group of children. Health assessments are also necessary to evaluate the existence of current health impacts related to pesticide exposures. However, we cannot await absolute scientific proof of harm while allowing known exposures to continue unabated. Adequate evidence already exists to demonstrate a public health problem. This evidence should justify action to protect the most exposed and most vulnerable among us from these poisons. If we protect this sentinel population of farm children, then we are more likely to protect all children. NRDC's recommendations for immediate action follow. (For an additional discussion of recommendations raised by farmworker groups, see *Protecting Farmworker Children from Pesticide Exposure: Recommendations* of a *Farmworker* Coalition, October 1998, Farmworker Justice Fund, Washington, DC.)

REGULATORY PROTECTION

- Designate farm children as a sentinel group that needs to be considered and protected in all tolerance decisions under the FQPA. If the higher levels and additional routes of exposure experienced by farm children are not considered in setting tolerances, this violates the child protection provisions of the law.
- Address current data gaps with regard to excess exposures among farm children by including an additional tenfold safety factor into threshold-based risk assessments for food tolerances. The FQPA requires use of such a tenfold factor unless U.S. EPA can demonstrate, based on reliable data, that all infants and children will be safe using a different safety factor. It is clear that with regard to farm children, there is disproportionate exposure, and uncertainty about the degree of exposure. Thus an additional child-protective safety factor should be used to set tolerances for any pesticides to which farm children could be exposed.
- Consider non-dietary routes of pesticide exposure for farm children in establishing health-protective food tolerances. Children receive a large daily dose of pesticides from indoor air and dust. In the case of farm children, these exposures are not just limited to'pesticides registered for household use. Risks to children from take-home exposures must be considered in setting tolerances for all agricultural pesticides.
- Phase out Category I acutely toxic pesticides, and phase out use of the most hazardous neurotoxic organophosphate and carbamate pesticides, endocrine disrupters, and carcinogens, while developing and promoting alternative pest management practices.
- Reevaluate post-application reentry intervals to account for children. If children are to continue to work legally in agriculture, then all reentry standards must be reevaluated to adequately protect children as recommended by the Children's Health Protection Advisory Committee.
- Reevaluate other provisions in the farm Worker Protection Standard (40 CFR Parts 156–170) to require that laundry services be provided for all "normal work attire" so that workers do not have to bring potentially contaminated clothing home, and that shower and locker room facilities be provided.
- Recognize that migrant farmworker communities are particularly at risk from pesticides and, in accordance with the President's Executive Order on Environmental Justice, take action to promote enforcement of key legal requirements that could help

protect this community under the FQPA and EPA pesticide rules, including the Worker Protection Standard.170

- Increase research into exposures and health status of farm children. Biological monitoring of pesticide residues in urine is particularly useful for assessing total exposure. As required by the Executive Order on Environmental Justice, U.S. EPA must "improve research and data collection relating to the health and environment" of farmworkers and must "ensure greater public participation" in study design. More scientific information will allow more informed decision-making.[170]
- Do not register pesticides for use in the environment unless there is an established laboratory methodology for measuring residues of the pesticide in environmental media and in the human body.
- Conduct targeted pesticide air monitoring in agricultural communities during major pesticide application periods to detect airborne toxic drift. Communities on agricultural-urban interfaces may be significantly exposed to airborne pesticides. Targeted monitoring will ensure compliance with existing regulations and will identify problem areas requiring mitigation.
- Children under age 18 should not be handling hazardous substances or operating machinery.89
- Provide affordable, accessible day care for all working families with young children.
- Inform workers about the identity of chemicals they may be exposed to, and the known or potential health effects of these chemicals. Only with full knowledge can they take action to protect themselves.
- Provide water, soap, and towels to agricultural employees to allow them to wash off pesticide residues routinely and after emergency exposures.
- Expand alternative agricultural programs such as integrated pest management (IPM) and increase funding for research on non-pesticide alternatives or organic farming practices. IPM programs have often been opportunities for public relations rather than true efforts at pesticide use reduction. USDA should adopt a formal definition of IPM that includes significant and measurable reduction of pesticide ***use*** and avoids use of all organophosphates, category one acute toxicants, carcinogens, and reproductive toxicants, and then take steps to promote this strategy nationwide.
- Encourage organic farming by instituting stringent national standards. Organic agriculture is an effective way to reduce pesticide exposures among farm families and the general public. USDA should encourage truly sustainable and healthy organic farming practices that provide affordable, high quality food for families.

OTHER RECOMMENDATIONS

- Create federal and state pesticide use reporting programs such as the current California program that requires pesticide applicators to report the quantity of pesticide sprayed, the acreage and crop treated, and the identity of the pesticides used. Such reporting systems facilitate research into potential health impacts of pesticides, strengthen pesticide illness tracking, can provide incentives for pesticide use reduction, and are fundamental for worker and community right-to-know efforts.

THE PRINCIPLES OF INTEGRATED PEST MANAGEMENT

Integrated Pest Management is rooted in the concept that pests can be controlled naturally through biological mechanisms and that a certain amount of pest damage is acceptable. Early IPM definitions applied ecological principles to agricultural settings, acknowledging the important role predators and parasites play in keeping pest populations in check. IPM was designed to utilize management tactics that prevent pest problems from occurring and to only use chemical control as a last resort.

IPM proponents developed the concept of an 'economic threshold," referring to the level of injury a pest can inflict before the loss sustained by a lowered crop yield outweighs the cost of taking corrective action. The practice of scouting fields for levels of pests, their natural predators ('good bugs"), and actual damage—before treating with chemical products-was also an early IPM innovation.

Over the years, the practice of IPM has strayed from its origins, with scouting and economic thresholds now often being used to decide when and with what to spray rather than developing strategies that enhance the effectiveness of biological control mechanisms that prevent the need to spray. In recent years, researchers and policy analysts have put forth new and improved definitions of IPM, which emphasize its ecological and prevention-oriented principles.

Examples of so-called "bio-intensive" IPM may be found in NRDC's Fields of Change: A New Crop of American farmers finds Alternatives to Pesticides, which also includes examples of pesticide-free organic farming.

- Reduce pesticide use in and around schools and day care centers. Reduction would require informing parents and teachers about pesticide use, requiring that all schools and day care centers have integrated pest management (IPM) programs, and creating buffer zones around schools located in agricultural areas. (See box above.) Furthermore, particularly hazardous pesticides should not be used in such facilities at all.
- Create funding support for regional laboratories with capabilities for precisely and accurately measuring low-levels of environmental toxicants in environmental media and human tissues. Such laboratories will allow for improved surveillance, improved exposure assessment in research studies, and the ability to respond rapidly to environmental disasters.
- Farmworker housing should be constructed within the urban growth boundary of rural communities rather than as labor camps surrounded by fields. In the labor camps, spray drift from fields is almost inevitable, and children play in or next to the contaminated fields.
- Collective bargaining rights are fundamental to farmworkers' ability to protect themselves and their families from pesticide poisonings. An organized workforce is a more informed workforce. Living wages are fundamental to decreasing reliance on child labor.
- Do not retaliate against workers for reporting health and safety issues, Only if workers feel safe in speaking out will surveillance of pesticide-related illnesses be effective.

PRACTICAL STEPS FOR INDIVIDUALS

Farm Owners

- Provide adequate washing facilities, including showers, and locker room facilities with change areas. Washing up with soap and hot water before going home to the children will greatly diminish take-home exposures.
- Provide laundry services for work clothes. Employers are required to provide laundry services for personal protective equipment. These programs should be expanded to include all work clothes.
- Educate workers about the health hazards of pesticides. Educated workers can handle chemicals more safely and protect themselves and their families.
- Provide child care. Child care facilities will allow families to work without bringing children into the fields.
- Do not allow children in or near fields during, and for an ample period of time after, pesticide applications. Reentry intervals must be prolonged to protect children.
- Preserve adequate spraying buffer zones between fields and housing or schools. Pesticide drift is a hazard to local communities and bodies of water.
- Clean pesticide mixing and application equipment at the end of the application season to prevent inadvertent contact exposure of workers and curious children.
- Select less toxic pesticides. Avoid using organophosphate pesticides, Category I acute toxicants, probable or possible human carcinogens, and reproductive toxicants.
- Support pesticide use reporting programs. These are useful to help develop farm-specific pest management plans and to evaluate the effectiveness of different pest management strategies.
- Use integrated pest management techniques (IPM) and, where possible, switch to non-pesticide alternative methods of pest control. Many farmers have had excellent success with reducing or completely eliminating pesticide use on their farms. Reducing or eliminating pesticide use is the only way to assure that human exposures will decrease.

Farmworkers

- Do not allow children to play in agricultural drainage ditches.
- Do not use agricultural chemicals indoors or around the home.
- Do not reuse chemical containers, or bring empty containers or contaminated equipment home.
- Do not wear work clothes at home.
- Remove outdoor playthings when pesticides are being sprayed in nearby fields.
- Do not wash work clothes with other clothes, particularly children's clothes. Wash work clothes with hot water, and handle them with gloves before washing.
- If clothes get soaked with pesticides, throw them away. Don't risk washing them or wearing them again.
- Do not pick up children after work before washing up and changing clothes.
- Your employer is legally required to teach you about the health effects of pesticides and how to protect yourself-you should not be asked to handle pesticides

without training. You should not have to work in a pesticide-treated field for more than five days without training.

▶ Your employer is required to provide protective clothing and equipment to anyone applying pesticides, and to wash and maintain the clothing and equipment

All Parents

▶ Avoid using pesticides in the home or yard, or storing pesticides in the home.

▶ Learn to recognize the health effects of pesticide exposures.

▶ Wash children's hands and toys frequently to remove dust.

▶ Avoid wearing outdoor shoes inside the home--change to house slippers or sandals or use a doormat and keep it clean.

↗ Find out if pesticides are used at your child's school or day care center, and in city parks and playgrounds. Campaign for reduction or elimination of pesticide spraying in the environments where your child spends time.

▶ Purchase organic food whenever possible. Food grown with pesticides can contain residues that expose your family, and also comes at a cost to farm children.

▶ Avoid using carpets, particularly thick carpets, in your home. They are reservoirs for contaminated dust. If you have carpets, vacuum frequently with a power agitator.

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Acute Toxicity Immediate, or short-term health effects.

Category I The most highly toxic substances of the four classes of pesticides in U.S. EPA's classification system. These substances cause death or severe illness in very small doses through ingestion, inhalation, and skin contact; they must be labeled "DANGER POISON."

Chronic Toxicity Delayed, or long-term health effects.

Degradation The breakdown of a chemical in the environment. Usually occurs via the action of sunlight, temperature, and microorganisms in the soil. This process can transform a toxic chemical into a benign chemical, or can create new, toxic breakdown products.

Endocrine Disruptor A substance which interferes with natural hormones.

Exposure Occurs when a person comes into contact with a chemical in their environment. May involve oral ingestion, inhalation, and absorption through the skin or the mucus membranes of the eyes, nose, or mouth.

Groundwater Water that flows in aquifers underground rather than in rivers, streams, and lakes on the surface. Groundwater is generally accessed via wells and is frequently used for drinking.

Hormones Natural chemicals produced by our bodies that are responsible for successful reproduction, development, normal behavior, and maintenance of normal body processes.

Integrated Pest Management (IPM) A pest management strategy that uses field monitoring of pest populations, established guidelines, and economic thresholds to determine if and when pesticide treatments should be utilized. Emphasizes the use of a number of crop management techniques including the conservation of natural enemies and the use of resistant varieties to manage pests.

LOEL/LOAEL Lowest Observable (Adverse) Effect Level, the lowest dose of a chemical that produces a measurable (adverse) health effect on a laboratory animal.

Metabolism The breakdown of a chemical in the body. Often occurs via the action of enzymes in the liver. This process can inactivate toxic chemicals or can create toxic metabolic products.

n-Methyl Carbamates A class of insecticide that interferes with acetylcholinesterase (see organophosphates) but acts reversibly rather than irreversibly. Nonetheless these pesticides can cause acute and chronic neurologic health effects. Examples of carbamates include carbaryl (Sevin®) and aldicarb (Temik®).

NOEL/NOAEL No Observable (Adverse) Effect Level, the highest dose of a chemical that does not produce a measurable (adverse) health effect on a laboratory animal.

Organochlorines (OCs) A class of insecticide of which DDT is the most well-known member. OCs are frequently persistent in the environment, and often accumulate in fat. Most OCs are known or suspected endocrine disruptors. Examples of currently used OCs include dicofol, endosulfan, methoxychlor, and lindane.

Organophosphates (OPs) A class of insecticide that was originally synthesized during World War II as a nerve warfare agent. Organophosphates irreversibly bind to, and inhibit, an important enzyme called acetylcholinesterase. This enzyme is responsible for rapidly breaking down a chemical (acetylcholine), which transmits nerve impulses in insects and humans alike. Failure to break down acetylcholine can cause numerous acute and chronic health effects. Examples of OPs include chlorpyrifos (Dursban®), diazinon, malathion, and parathion.

Pesticides Any chemical substance intended to kill pests, including herbicides (to kill weeds), insecticides (to kill insects), fungicides (to kill mold), and rodenticides (to kill rats and mice).

Quantitative Risk Assessment The characterization of the health effects expected from exposure to a toxicant, estimation of the probability of occurrence of health effects, the doses at which these health effects may occur, and recommendation of an acceptable concentration of the toxicant in air, water, food, or in the workplace.

Reference Dose (RfD) A dose of a pesticide that the U.S. EPA considers safe for regular daily consumption by humans without adverse health effects. Generated by taking the NOAEL from animal studies and adding uncertainty factors to account for differences between animals and humans, and susceptibility within the human population.

Serum The liquid portion of blood with the red and white blood cells removed. Often used for measurement of chemical substances in the body.

Toxic Damaging to health.

Toxicant A chemical that can produce adverse health effects.

Threshold A level of exposure below which no health effects are expected to occur.